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SYSTEMS AND PROCEDURES QUARTERLY

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"... to provide a means for the study and dissemination of knowledge relative to systems and procedures through research, discussion and publications"

— from the Association's By-Laws

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ELECTRONICS:

Boon . . . or Bane?

by H. A. Warner

AN EXPERT TAKES AN IMPARTIAL LOOK AT THE PROS AND CONS OF ELECTRONICS IN BUSINESS

ELECTRONICS is a mighty fascinating subject; since radio and television now reach nearly every mortal in the country, electronics is a subject with which nearly everyone has daily contact. Electronics literally opens the doors to railroad, bus, plane stations, and other public places. We're informed, entertained, warmed, fed, even lulled to sleep by devices wholly electronic, or controlled by electronics. What do we mean by "electronics?" What is this word which has gotten so close to us in recent years; so close that everyone feels its impact in one way or another every day? Let's take a look at it.

The dictionary and the encyclopedia tell us that electronics is the branch of physics and electrical engineering dealing with the emission and flow of electrons, particularly in such devices as the vacuum tube. Now, there's a nice definition; but what's an electron? An electron, they tell us, is the smallest unit charge of negative electricity. And because the electron will flow from one part of a vacuum tube to another, and can be controlled in doing so, we have X-ray machines, television, radio, radar, facsimile transmission, even adding machines which work at incomprehensibly fast speeds.

Let's recap for a moment some of the systems and procedures impact of the vacuum tube; let's see if it's just a novelty—if, to coin a phrase, "it's here to stay."

Not Too New

First thing we discover about the electron tube is that it may not be as new as we think it is. Actually, it was back in the teens that Lee de Forest first enunciated the principle, and built the first tubes. And for his pains he got into hot water. In fact, to our shame, we weren't too eager to whisk de Forest's tube into use. But get into use it did, and proved to be the means of building a whole new entertainment and manufacturing industry almost overnight.

We learn also that isolated ("non-integrated," if you will) applications of the tube took place in the factory in what we might call "the early days" for such purposes as inspection (using the X-ray, and other properties), switching, color control, timing of machine cycles and

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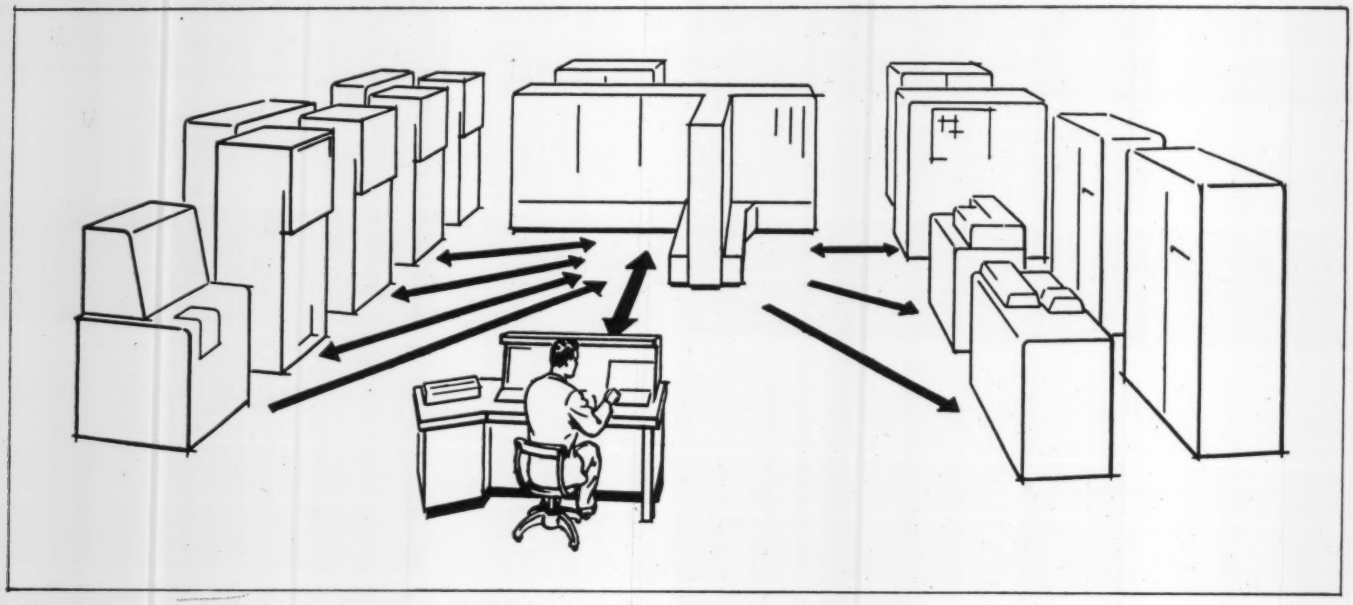
Mr. Warner, a native of Bayonne, N. J., studied Mechanical Engineering at Pennsylvania State College. For more than a decade, Mr. Warner served a large metropolitan bank in systems and methods work, studying mechanization in the office and specializing in the application of punched cards to record keeping and accounting tasks. In addition to doing methods work for a large pulp and paper producer, he served as technical director of the National Office Management Association. Since 1951, Mr. Warner has been doing management consulting work with the Hurlsley Management Institute in Baltimore.



Schematic of Console Control in the IBM 705 electronic data processing machine. *Courtesy IBM*

materials flow. Quite a few industrial applications, in fact, had been made before J. Presper Eckert and John Mauchly assembled their ENIAC, or IBM announced its calculating punch "with radio tubes in it!" In fact, it was the mid-forties before the public became conscious of the fact that the vacuum tube was emerging as a toiler in office and laboratory, as well as an entertainer in the home.

Brains

Spurred by Western Electric's tracking and aiming devices, and scientific computing assemblies especially concocted for military and research reasons, the writing fraternity (especially the magazine and Sunday supplement sections) brought forth, during the late forties and early fifties, a multitude of articles dealing with "Electronic Brains," "Thinking Machines," "Giant Logicians;" and the illustrators had a hey-day a la Artzybashev drawing octopi with human faces, pipe and wire arms, and bodies of glass and plastic obviously (couldn't you see the zigzag flashes of current, coyly emphasized in brilliant colors?) turning out answers by the quintillion—and, we inferred from some of the text, reasoned, thinking, logical answers.

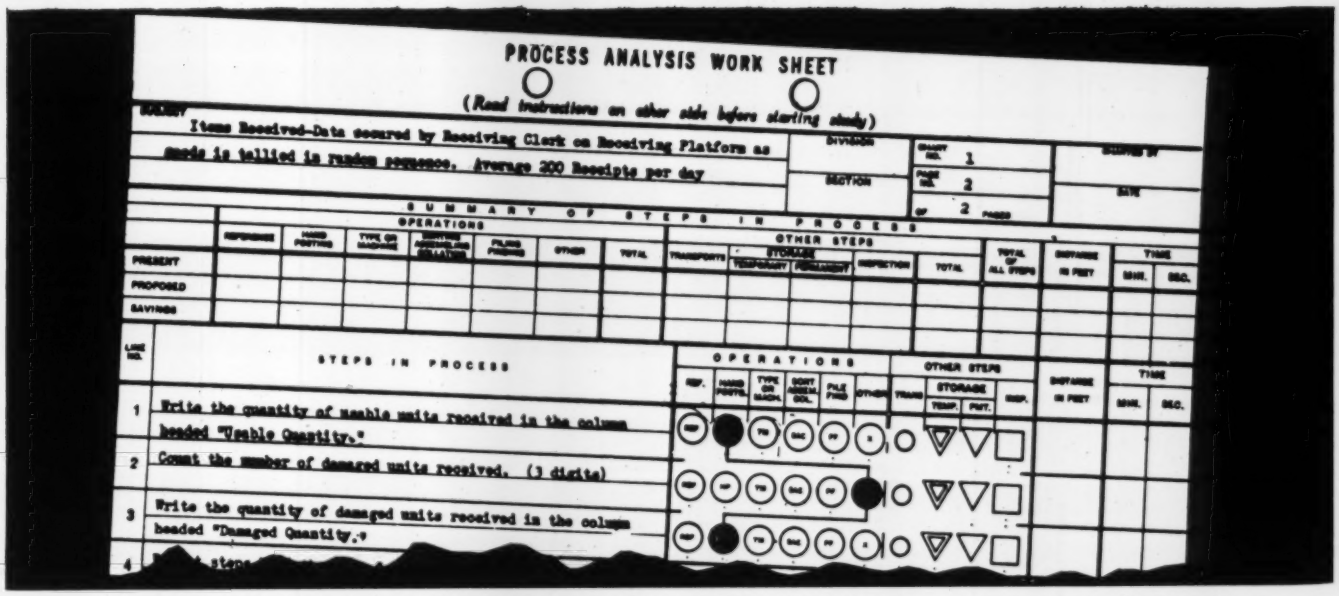
We'll leave it to the long-hairs to argue as to whether a machine can be built to think, or no. Let the professors (and maybe a railroad and a business machine maker) labor over the definition of the word "think." Obviously that word must be defined before we can tell whether we can make a machine to do it. While the cloistered boys and girls set up their mathematical models and their controlled multiple choice circuits we discover in industry and the office that the electronic device can "think" only if a human has thought before. Under our current conception of the word "think," which might be capsulled "original reasoning and judgment, or deciding," the machines may "think" thousands of times faster than we can, provided we've thought the problem through originally, and have told the machines what to do.

Fly in the Ointment

Lest readers misjudge, let's hasten to say that this is not developing into a long diatribe against (or for) anything. Rather what we're attempting to do is to set down in orderly manner a few simple thoughts about where we're going in mill and office with our little servant the vacuum tube. And what we've discovered is a fly in the ointment, a mote in our eye, a colored gentleman in the nitrocellulose fiber supply—we've tumbled onto the fact that we cannot do without people. All that reading we did about giant electronic brains which made us think in terms of one lone man pushing buttons for everything was a pretty bum steer. We'll not only need that guy—but many more men and women too. We'll need people wherever there's an exception to a mechanical routine (that is, something which we haven't converted thinking to a routine action—or, in the lingo of the biz, we haven't "programmed").

Not a Big Fly

But is that bad? Indeed not; in fact, it's pretty obvious that the impact of electronics in the office as well as the mill will make us think sooner or later. Actually, we've heard it said and have read it many times, but here it is again: *The systems and procedures improvement resulting from the study of whether or not to install elec-*



PROCESS ANALYSIS WORK SHEET

(Read instructions on other side before starting study)

Items Received-Data secured by Receiving Clerk on Receiving Platform as goods is tallied in random sequence. Average 200 Receipts per day

SUMMARY OF STEPS IN PROCESS

	OPERATIONS							OTHER STEPS							
	INSPECTION	HAND POSTING	TYPE OR MACHINE	SORTING, COUNTING AND RELATING	FILING, POSTING	OTHER	TOTAL	TRANSPORTS	STORAGE TEMPORARY	STORAGE PERMANENT	INSPECTION	TOTAL	TOTAL OF ALL STEPS	DISTANCE IN FEET	TIME MIN.	TIME SEC.
PRESENT																
PROPOSED																
SAVINGS																

LINE NO.	STEPS IN PROCESS	OPERATIONS							OTHER STEPS				DISTANCE IN FEET	TIME	
		INSP.	HAND POSTG.	TYPE OR MACH.	SORT ARRGE. COU.	FILE POST.	OTHER	TRANS.	STORAGE TEMP.	STORAGE PERM.	INSP.			MIN.	SEC.
1	Write the quantity of usable units received in the column headed "Usable Quantity."														
2	Count the number of damaged units received. (3 digits)														
3	Write the quantity of damaged units received in the column headed "Damaged Quantity."														
4															

Sample process analysis chart usually prepared as part of programming operation. *Courtesy Sperry Rand, Inc.*

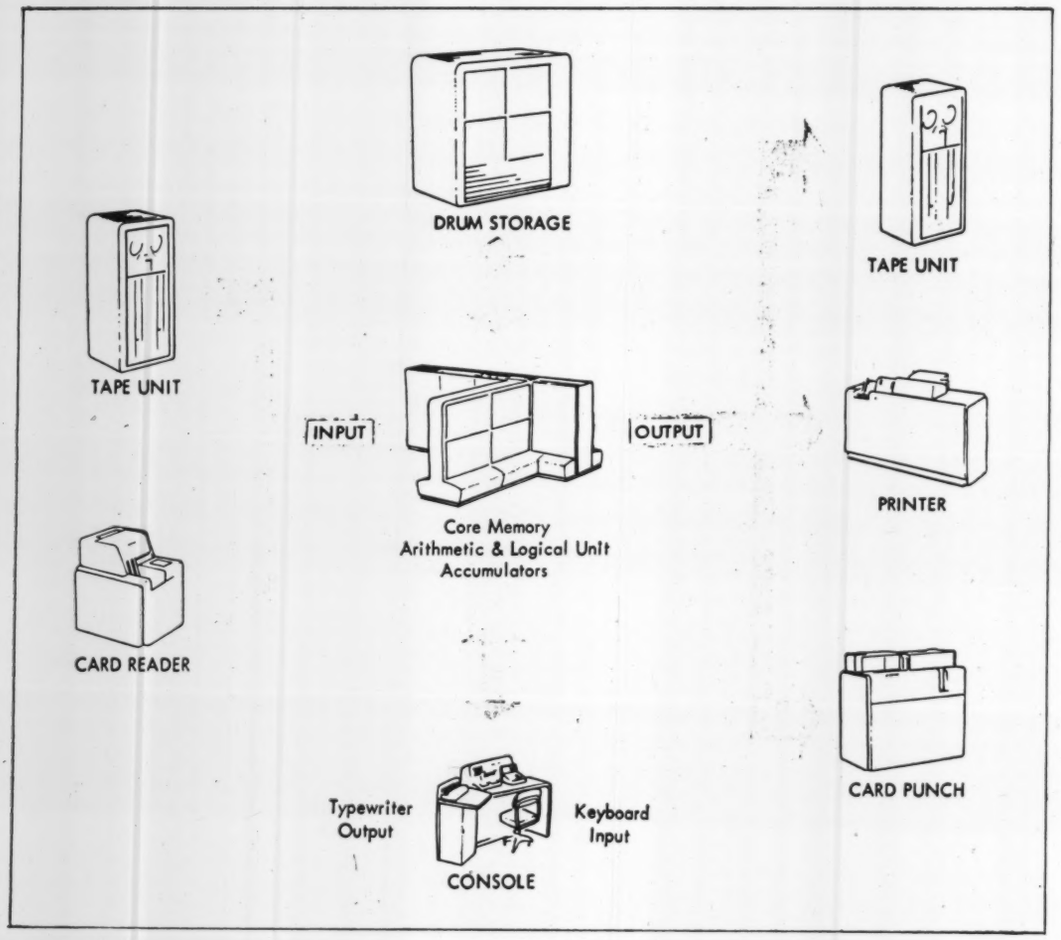
tronic data handling is many times more valuable than its cost even though the decision may be not to install electronic equipment. Clear in phrasing such as this, of course, is the fact that at least indirectly electronics may have "boon" tendencies—just as with the older punched card mechanization, so with electronics the beneficial results of studying the situation will more than pay their way.

We say "beneficial results of studying" advisedly. They're beneficial only if we do something about them. If nothing's done, our study money has been wasted, and we risk something worse than a waste of money: waste of people—for the disillusioning effect of study without action will drive good people away "sure as shootin'!" Not only does inaction after study denote an *indifferent* management, but also it points the finger at a lack of understanding in management.

The rule of reason, backstopped by the weight of experience, pretty well leads us then, to the conclusion that the systems disclosures of looking into any mechanization (and particularly electronic mechanization), if acted upon, cannot fail to benefit, if not "boon." What about the decision, though? If it's "No electronics," but we assume that the systems suggestions developed are carried through, then it is OK. But what if the decision is "Yes"? Are there "boon or bust" implications in our choice of specifics? Are there rights and wrongs to be watched as we introduce electronic devices? Let's look into it a bit.

Volume and Velocity

First, a comment or two about two mighty important words, both beginning with the same letter: "Volume and Velocity. They're the words of giant stature in mechanization studies. "Volume" means primarily how much work is done; "Velocity" means how fast it is done. But, secondarily, volume means how many relationships, or how many accounts; and executives sometimes confuse the secondary meaning with the first, and start a perfectly horrible snafu by doing so. We've found by experience it's best to amplify (we're not speaking electronically yet) our "V-V" thinking by the word "Activity." Letting activity sub for our primary meaning of volume, we come up with: "Volume means base of activity; activity means how much work is done; velocity means how fast it's done." Expressed in numbers, we have a volume of 100,000 accounts, on which there is activity of 10,000 postings, at a velocity of 1,000 postings per day. All other things being equal, there'd be five times as much posting work if we had 50,000 postings, ten times as much posting work if we had a posting to each account; but there'd be some variation in the clerical assistance needed for posting. Given all the load at one time, our finding time with 100,000 postings would be zero, for we would obviously, sort all the posting media to account arrangement and have clear sailing. With 50,000 postings, though, not only would we have to sort—we'd also have to locate each account card. On the average, every alternate card would be posted, so our finding time would be smallish. With 10,000 postings, though, finding time bulks a bit—and we might have a very random scatter, so that even with our posting media sorted into account number order, we'd have wide variations in skipped account cards. If, moreover, we were to receive our work in daily batches of 1,000, and we had to post daily, we'd have a tiny sorting problem, but a comparatively staggering finding problem.



Data transmission in the IBM 705 electronic data processing machine.

Courtesy IBM

Before we'd conclude we should order a Little-Dandy-Oh-So-Handy electronic arranger, finder, and poster, though (at a rental of $14,000 a month), we'd obviously try cycling our work, less frequent posting (if we could post quarterly instead of monthly, for instance) rearrangement of clerical work load and work stations so as to backstop our posters. We'd also try, if our operation is small loan uniform payments, insurance premiums (uniform), vacation and other special purpose uniform amounts, not posting ("negative bookkeeping,") and what a work saving there! And, to look at it sadly indeed, if we found a high proportion of exceptions to the routine items which couldn't be stopped (???), we'd conclude never to hire a Little Dandy—we'd point out clearly in that case that people are the only ones who can handle individual situations.

Rent a 'Little Dandy?'

However, we've found that this business we're studying has postings in irregular amounts, at varying intervals, and can't be regularly cycled, but has a 95% uniformity in routine. From the figures above, do we conclude now to rent that Little Dandy? What would a top executive think of a systems man who suggested hiring a machine which can

> Find at the rate of 3,000 to 3,000,000 things an hour;
> Post at the rate of 30,000 to 300,000 things an hour;
> File at the rate of 3,000 to 3,000,000 things an hour;
> and transcribe 130 character lines at the rate of 6,000 to 60,000 lines per hour; and
> Rents for $25.00 to $200.00 an hour to do work which amounted only to a maximum of 2,000 items a day?

'Sledge-hammer on a Tack'

Obvious, isn't it? What's obvious? That attacking any clerical chore which does not involve heavy activity and high velocity with electronics is using a sledge-hammer on a tack. (Per John Coleman, president Burroughs Corporation). In fact, leaving volume out of our thinking may be quite safe for 1,000,000 accounts (high volume) which don't get posted, have no activity and no velocity; whereas a group of 200,000 accounts each posted once or more a month gives us activity of 200,000 plus a month, and velocity of 10,000 items a working day on the average. So we'll be wise enough, we hope, to avoid one bane, and to develop volumetric tables which will point out to us when our work begins really to justify thinking of elec-

tronic labor. The fundamentals are pretty clear: When (and only when) the handling cost of the top velocity which must be met is less in terms of total machine rental (or amortization) plus clerical salaries for operators than the total straight clerical salaries alone does mechanization justify itself from the point of view of cost.

From the point of view of flexible handling, only when the clerical task can be reduced to almost inflexible routine can an operation utilize the more advanced mechanizations such as punched cards or electronics. In electronics, the machining of even a simple routine requires exhausting analysis, programming involving perhaps hundreds, certainly scores of pages of instruction to the computer, all in step-by-step precise sequence and arrangement so as to produce one result. Those who have done it, tell us that it may take six man months to program an operation which can be done in six minutes on an all purpose machine. Programming is simpler with the limited or "special purpose" machines—but because they are special purpose, we may not be able to vary our routine within any wide limits. Obviously, no one-time jobs must include the cost of programming when evaluating them economically. Will we be wise enough to shy away from the bane of "flexibility?" Flexibility of this kind and low unit cost just don't go together—the industrial engineers tell us this from years of experience.

Conclusion

Can we adduce anything from all the gobbledegook which we've read so far? Perhaps; how's this for a starter: There's at least one boon in electronics—just studying it with our systems will improve our thinking and get us closer to our business even if we do no more. If there is sufficient activity and velocity to justify it, and can follow rather rigid routines, unit cost can be cut considerably. But there are banes: If we forget, and try to "electronify" with low velocity and wide variation, we're apt to lose our company's shirt (and maybe our job). So, in the last analysis, whether electronics proves boon or bane to us is up to us—if we remember those three things, activity, velocity, and inflexibility.

Training

The more advanced the mechanization, the more thorough the integration, the more training we'll have to absorb—ourselves, our associates, and our clerical helpers. Courses totalling six months of time plus on the job experience of equal amount are required just to start us on logical operation and programming for one of the medium-size general purpose computers.

Such specialized training cannot, of course, be given to all our clerical people, so we become quite dependent in many instances on certain individual persons who require the training for the proper operation of the equipment. As long as routine prevails and no exceptions occur, or as long as we don't want to extend the application of electronics, such training may be limited to a few operators. But when extensions of application or modifications occur additional trained personnel is required.

Dependence

Just as we are dependent on the trained people only, so are we dependent on the equipment. Here the dependence is quite absolute. For unless we have retained another record keeping medium (sometimes an impossibility because of cost), we have no other way of getting our facts. In truth, electronics, while they may revolutionize some records, also are frighteningly efficient in creating utter dependence upon them. Never before since records have been kept have we been so completely at the mercy of a machine—with punched cards, at least we can *see* a hole in a card, but with a magnetic tape we can't see a thing! As our dependence upon the equipment increases, we must take steps to prevent or at least control equipment failure. Many manufacturers provide checking circuits, automatic reprocessing and other built-in features in the equipment. But the risk is still apparent—tapes may become demagnetized through no human fault, power supply may fail (as it often does in severe storms or under flood conditions), foreign matter may enter the equipment and affect its circuits and required air conditioning may fail.

Service

Maintenance and distress service from manufacturers has been exceedingly good in actual practice. In fact, no instance of utter failure or complete blank has so far come to light—manufacturers have been above criticism in backstopping their electronic office equipment thus far. This then simmers down to a user being willing to gamble successful application of equipment on ideal conditions, enough trained operating personnel, and continued flawless performance of service people.

That's all there is to it, in simple language: given enough activity and velocity and fixed routines, proper training of selected people and willingness to gamble on perfect performance, we may enjoy the boon of fast (incredibly fast) record keeping and reporting service at really low-unit cost. **s/p/a**

"How We Cut Reproduction Costs One-Third"—John P. Baldwin & Francis Palmer Jr., *Office Management*, September 1955.

Detailed discussion of study made of costs of reproduction of engineering drawings. Savings were made by reducing size of drawings prior to reproduction and treating them for offset.

Internal CONTROL and System

by Walter W. Merrill

INTERNAL CONTROL is a much used term which some of us may think is greatly overworked. A little consideration will indicate, however, that the concept of internal control is an extremely important one, not only to the auditor, but to the systems analyst as well.

There are many definitions of internal control. Perhaps the most authoritative one, given by the American Institute of Accountants in their booklet, "Internal Control," reads as follows:

> "Internal control comprises the plan of organization and all of the coordinate methods and measures adopted within a business to safeguard its assets, check the accuracy and reliability of its accounting data, promote operational efficiency, and encourage adherence to prescribed managerial policies."

The outside auditor, the internal auditor and the systems analyst are all interested in internal control, although perhaps from different points of view. It is the function of the outside auditor to submit a statement to his client to the effect that in his professional opinion the financial statements of the client correctly state the financial condition of the business. Obviously, in order to make such a statement the outside auditor must either check a very large number of transactions or depend to a large extent upon the client's books of account. He cannot depend on the client's books and records unless the client's internal control over financial transactions is such that these records are accurate and reliable. Contrary to popular thought, the outside auditor is not employed primarily to detect fraud, although frequently the audit procedures followed by the outside auditor are such that fraud is uncovered.

Now, what is the system man's relationship to internal control? Obviously, if he installs systems, he exerts a strong influence on the degree of internal control which is built into these systems. To say the least, it would be highly embarrassing for him if his highly efficient and highly stream-lined system, after being in effect for six months, was severely criticized by either the outside auditor or the internal auditor on the ground that it resulted in important weaknesses of internal control. Should one of the bookkeepers make off with a few thousand dollars because of a weakness in the system, I dare say he would be somewhat more than embarrassed.

Now, what are the basic elements of internal control? There are six of them. The first is the proper segregation of functions and duties so that no one individual has complete control of a transaction or function. This is perhaps the most important and the one with which systems analysts will be most concerned. However, there are other requirements for good internal control, as follows:

> Integrated policies and procedures so that all levels of management know their objectives.
>
> Qualified personnel, able to properly discharge the duties and responsibilities entrusted to them.
>
> Proper execution of procedures.
>
> Realization of the importance of internal control, and last but not least,
>
> Some provision for auditing and review of procedures and transactions to see that the policies of management are being carried out.

The ultimate responsibility for internal control rests not with the auditor nor with the systems analyst but with management itself, that is to say, top management, particularly top financial management. Unfortunately, there are many situations in which both the auditors and the systems analysts are aware of a need for improved internal control, but top management remains unconvinced. In these cases it is up to the auditor or the systems analyst to do a selling job. I am reminded of a story in which a public accountant was attempting to convince a prominent industrialist that his company should have better methods of internal control. This industrialist

DESIGN

claimed to know all of his employees personally, and knew they were all honest. He told the accountant that, under these circumstances, there was no need to worry about internal control. The accountant thought for a moment and then turned to him and said, "Mr. Blank, do you think it is fair to place temptation in front of these people every day, hoping that they won't yield to it?" The industrialist considered the problem, and finally he turned and said, "Well, I guess you win. Go ahead with your internal control."

I would like now to give a few examples of the weaknesses in internal control which, although they appear obvious, one might say elementary, frequently occur. The first area I would like to discuss is that of accounts payable. In this area an embezzler has two requirements if he is to perpetrate a fraud and not be caught. First, of course, he must obtain possession of the money or other asset and, secondly, he must find some place to "bury the charge" on the books of account. Dwelling for a moment upon this second point, those companies which have regular operating expense statements which are thoroughly reviewed and analyzed, or which have budgets and standard costs, are in a much better position to prevent the potential embezzler from burying a charge than are companies which have too many miscellaneous accounts or suspense accounts which are never analyzed or reconciled. Those of you who are trying to sell good expense control to your companies can perhaps use this as an additional argument.

A frequently encountered weakness in internal control of accounts payable occurs in the following situation: The accounts payable department matches the invoice against the purchase order and against the receiving report, checks the extensions, makes up the check and then sends the check with the invoice and supporting documents to the treasurer for signature. The treasurer signs the check and then returns both the checks and the voucher to the accounts payable department, where the invoice and supporting documents are canceled and the check is mailed out to the supplier. Obviously, in this situation there is nothing to prevent the accounts payable department from putting through an invoice a second time or pocketing a check instead of mailing it. Thus, we come to the basic rule that invoices and supporting documents should be canceled or marked "Paid" by the treasurer or his representative before they are returned to the accounting department, and that the checks should be put in the mail by the treasurer or his representative and not returned to the accounting department at all.

Other frequently encountered internal control weaknesses include the following:

Storekeepers placing purchase orders, receiving merchandise, and approving invoices without any other employee being involved in the transaction.

Companies by-passing internal control checks in the case of discount bills which are paid prior to the receipt of merchandise.

Paymasters making up and distributing payrolls.

Payroll departments reconciling payroll bank accounts.

Bookkeepers receiving cash and posting to accounts receivable ledgers without the pre-establishment of control over cash.

These examples are elementary in nature and have been included only to illustrate some of the types of weaknesses which are often encountered, and to point out to the systems analyst the need for careful analysis of what seem to be minor procedural details.

Now, systems analysts may ask where they can get information on internal control. I have already referred to the booklet on "Internal Control," published by the American Institute of Accounts. Beyond that, any good systems text devotes space to internal control, and, finally, many public accounting firms prepare internal control questionnaires which they apply to client's procedures when they come in to make an audit. Most such firms are only too glad to discuss internal control problems with company systems personnel. **s/p/a**

Mr. Merrill is Director of Management Advisory Services in the Boston office of Price Waterhouse & Co. He is a Certified Public Accountant of Massachusetts and has served as President of the Bay State Chapter of SPA. He received his formal education at Princeton University and the Harvard Graduate School of Business Administration and served as a Lieutenant in the U. S. Naval Reserve during World War II.

WAITING LINES

in Office Operations

IF WE THINK OF COMMUNICATION in the broad sense of information transfer, office activities constitute the major elements of any company's internal communication system. The specific design of office operations will largely determine the over-all speed of communication in a given company. The impact of communication speed on the ultimate effectiveness of company operations is extremely significant.

Consider, for example, the role of communication speed on a large ship, such as a destroyer. If it took ten minutes to get a message from the combat information center to the bridge and another ten minutes to get a message from the bridge to the engine room, the combat effectiveness of a destroyer would be almost nil. In fact, it would be nearly impossible to get such a ship into a harbor. This is not too unlike the company whose executives get January information in March and April. How quickly can such a company react to changes in its operating environment?

And company reaction time is not the only important factor affected by communication speed. Every extra day that is required to process a purchase requisition adds to procurement lead time and ultimately raises inventory levels. Every day required to process a sales order adds to minimum delivery time and subtracts from the over-all value of the company's product. The time required to cash checks creates a reservoir of unavailable money, increasing a company's need for working capital. Almost every office operation involves direct penalties for processing delays.

In this discussion we will consider the problem of waiting lines, a rather different aspect of office system design which also has an extremely important influence on communication speed within a company. There is a very simple way to determine just how much communication speed is affected by waiting lines in a given situation. First, measure the total time a given message takes from the moment it originates until the moment it has reached its final destination. Next, calculate the total number of man-hours of processing and moving time that have been expended throughout the entire handling of the message. The difference between these two times is pure waiting time. For example, in a particular company a purchase requisition (certainly an important message) has an average elapsed time for 40 working hours from the moment it is initiated by a stock clerk to the moment it is released to a vendor. Total processing time and moving time average less than one man-hour. The other 39 hours are waiting time.

In this case, which is certainly not an uncommon one, doubling the various component processing rates would have almost no detectable effect on the time required to get a requisition from the stock clerk to the vendor. This is because of the domination of waiting time which may be entirely unaffected by changes in the processing rates of the various component operations. Thus, if communication speed is important, there appears to be good reason to take a close look at the nature of waiting lines.

We might best begin by examining a specific office situation. Consider for example a central stenographic group fed by a dictating network serving many offices. Suppose that for several hours we observed the time of arrival and work content of individual jobs from the various dictating stations. The lower set of lines on Exhibit I serves as a convenient representation of these observations. Each line treats a specific job. The beginning of the line identifies the time the job arrived and the length of the line (using the same time scale) represents the number of minutes that would be required to process the job.

Suppose, for the moment, that this group has an unlimited capacity to process jobs. In this case the graph also represents the number of jobs in this office at any given time, since capacity is so large that every order can be processed as soon as it arrives and may be expected to depart as soon as it is finished. The upper graph on the same page shows an actual count of the number of orders in process under such an assumption. Note that

by George J. Feeney

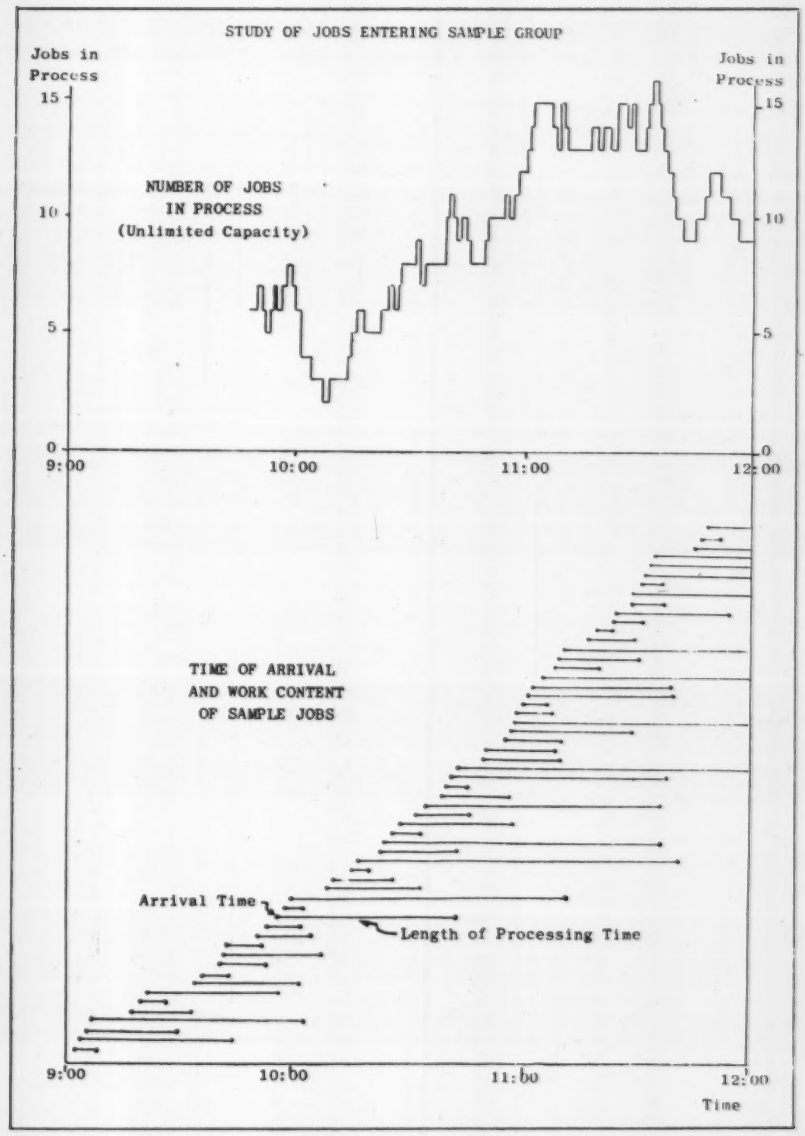


EXHIBIT I. Study of jobs entering sample group, which in this case, is a central stenographic group fed by a dictating network serving many offices.

no more than 16 jobs are in the office at any given time during the interval that was studied. Thus, the graph would be a correct description of the number of jobs in the office at any given time so long as the capacity of the office is at least 16. Note that we are using the word capacity in a very specific sense, to define the largest number of jobs that can be worked on simultaneously. Thus, capacity measures the number of operators present.

Suppose the capacity were less than 16, say 12. During periods when more than 12 jobs were available for work, some jobs would have to go into a waiting line. Thus, during some periods there would be more jobs on hand than are shown in the graph, reflecting the processing delay created by the waiting line.

It is interesting to reflect on the general relationship between capacity and the waiting line. When no waiting line exists, work output is limited by the number of jobs in the office. On the other hand, the existence of a waiting line permits full utilization of capacity. If total output capacity is greater than the average rate of input of work into the office, the existence of a waiting line thus creates a state in which output exceeds average input, and thus the waiting line tends to decrease.

Note that this pressure to decrease the waiting line is proportional to the difference between capacity and average demand but is independent of the specific size of the waiting line. If capacity is exactly the same as average demand, then the existence of a waiting line creates no pressure to reduce the waiting line. In such a situation, waiting lines may increase without limit. No matter how large a waiting line becomes, there is nothing to prevent it from becoming larger. Work is flowing out no faster than it is flowing in.

In the specific case we examined earlier, jobs arrived at an average rate of 20 per hour and had an average processing time of one-half hour. Thus, the average num-

ber of jobs in process might be expected to be 10. (This is confirmed by inspection of the sample data.) Over any long period of time we would expect this average to prevail. Therefore, over a 40-hour week we would expect a total demand for about 400 man-hours of work. Note that this average work requirement is not affected by the capacity of the office. The only thing that is affected by capacity is the character of the waiting line.

Stating the problem in more general terms: In any situation in which demand is variable from moment to moment but capacity must be fixed over relatively long periods of time, waiting lines may be expected periodically unless a large excess capacity is present. These waiting lines represent a delay in the processing of individual messages and, consequently, they slow down the internal communication system of the company. Such waiting lines can be eliminated only through the use of excess capacity which is not actually needed to meet the average long-period output requirements of the office.

General Approach

Since the conditions stipulated, fixed capacity and variable demand, are common in office operations, the waiting line problem appears to apply to a large number of situations. An acceptable approach to system design must balance the cost of excess capacity against the cost of delay in communications.

Such a balance can be achieved only if the planner can anticipate the expected delay time associated with any specific assignment of capacity. The purpose of this discussion is to show that methods exist which will permit exact analysis of this relationship between process capacity and delay time.

Note that this problem is not peculiar to office operations. The design of telephone trunking facilities involves precisely the same conflict between excess capacity and service delays. How many checkout counters should be installed in a supermarket? How many tellers should be available in a bank? How many maintenance men should be available for a large bank of automatic machines? Although each is in a very different context, all of these questions involve the same basic problem.

Fortunately, a great deal of work has been done on problems of this type, particularly in regard to telephone trunking and machine maintenance. Out of this work and a large amount of previous work in probability theory has evolved a general technique called waiting line theory. It will be useful to examine the manner in which this approach handles a waiting line problem.

Suppose we define the "state" of the office at any given time as simply the number of jobs on hand, including both jobs being worked on and jobs in the waiting line (if any). By saying, for example, that the office is in state 12 we simply mean that 12 jobs are on hand.

Waiting line theory deals with the probabilities of change from one state to another. Clearly, the probability of an increase in state is related to the rate at which jobs are expected to arrive. The probability of a decrease in state depends upon both the length of time required to process an individual job and the total processing capacity of the system.

Through mathematical analysis of these probabilities of change of state it is possible to determine the share of the time that the system will be in any particular state. Under certain conditions, discussed later, the entire computation depends on only two aspects of the system. The first aspect, as might be expected, is the total number of operators available, the capacity of the system. The second is the average number of operators required in the system. This is determined by multiplying the average rate at which jobs are received by the average operator time required to process a single job.

Unfortunately, even under these conditions, the actual analysis is relatively complex and it would be beyond the scope of this discussion to attempt to cover the method in detail. Actually, our main purpose is to point out that such an approach does exist and to examine some of the uses that might be made of waiting line theory. For those interested in examining the specific mathematical analysis several good books are available. (The best known reference in this field is "Probability Theory and its Applications," by William Feller, Wiley, 1950.)

Specific Results

A better picture of the application of waiting line theory might be presented through an examination of specific results. Exhibit II, on the next page, shows the actual results of such analysis in a situation where the average number of operations required is 10 (as in the specific example discussed earlier).

The upper chart in Exhibit II shows the percentage of time any given number of jobs will be in the office assuming actual capacity is 11, 12, 13, or 14 operators. For example, this chart shows that with a capacity of 11 operators, the office will have 10 jobs on hand about 7 percent of the time, 16 jobs on hand about 4 percent of the time.

The lower chart on this same page shows the cumulative form of the individual percentages. This may be interpreted as the percentage of the time that no more than a given number of jobs will be on hand. Thus, with a capacity of 11 operators, the office will have no more than 10 jobs on hand about 30 percent of the time and no more than 16 jobs on hand about 60 percent of the time. As might be expected, the amount of time that a large number of jobs are on hand diminishes rapidly as capacity is increased.

Whenever the number of jobs on hand is greater than

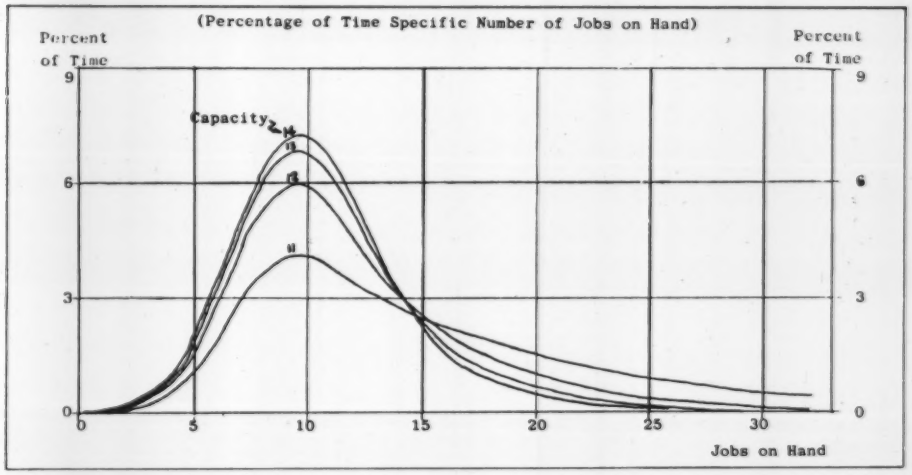
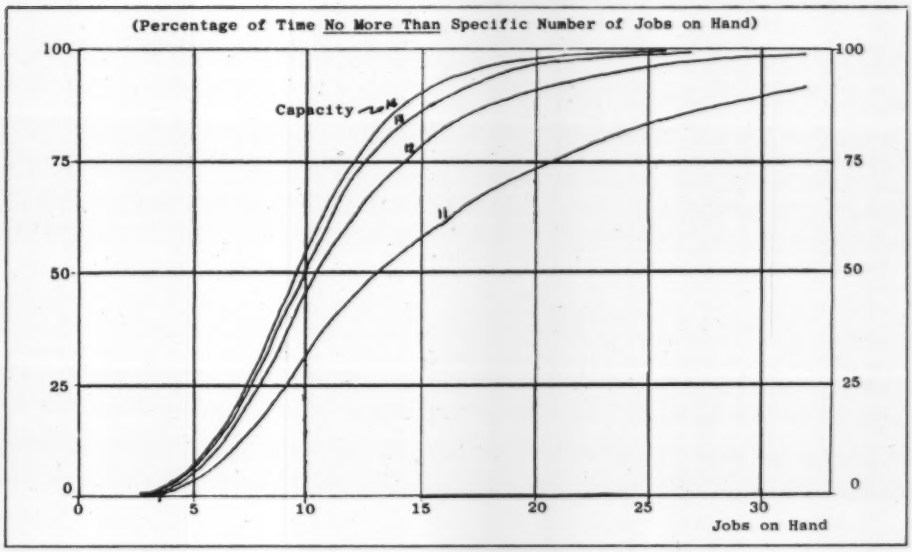


EXHIBIT II. Pattern of jobs on hand under various capacities is shown in these two charts. The upper chart shows the percentage of time any given number of jobs will be, assuming actual capacity is 11, 12, 13 or 14 operators.



This lower chart shows the cumulative form of the individual percentages.

the specific capacity of the office, a waiting line exists. Since the size of the waiting line is equal to the difference between the number of jobs on hand and the specific capacity, we can easily translate the analysis of the percentage of time that any given number of jobs are on hand into a statement of the percentage of time that any given number of jobs are in the waiting line.

Through further analysis of the percentage of time any particular waiting line will exist it is possible to determine the average size of the waiting line. In many situations a satisfactory description of the relationship between waiting lines and any particular capacity assignment may be available through a statement of the average size of the waiting line and the upper limit beyond which the waiting line does not grow in most instances, say 90 percent of the time. The 90 percent limit on the number of jobs in the office situation we have discussed may be read directly from the cumulative chart on Exhibit II. Taking into account the particular capacity represented these limits may be translated into 90 percent boundries on the size of the waiting line. Introducing also the computed average waiting lines, the following table may be constructed:

Capacity	Average Waiting Line	90% Limit on Waiting Line
11 operators	7 jobs	19 jobs
12 operators	2 jobs	7 jobs
13 operators	1 job	3 jobs
14 operators	½ job	3 job

Thus, in the particular situation studied, if 11 operators are available the waiting line will contain 7 jobs on the average and will contain no more than 19 jobs 90 percent of the time. If, at the other extreme, 13 operators are available, the average waiting line will contain 1 job and no more than 3 jobs will be in the waiting line 90 percent of the time.

In this example the average processing time was one-half hour per job. Given an 11-operator capacity we

would expect about 22 jobs to be processed per hour. Since, as shown above, the waiting line contains about 7 jobs on the average if the capacity is 11, we may expect the average delay in this office to be about one-third of an hour or twenty minutes if such a capacity is assigned. Note that this nearly doubles the actual time required to put a job through this office.

The delay time consequences of any specific assignment of capacity might have been illustrated in a variety of ways quite different from the average waiting line and 90 percent limit constructed above. The important point is that a technique exists which may be used to develop an exact statement of the relationship between the amount of capacity assigned to an office operation and the pattern of waiting line delay that will develop in the operation. Knowledge of such relationships will permit the office planner to anticipate waiting line problems and assign a final capacity to a given operation which balances the cost of processing delay against the cost of extra capacity.

In this example computation of waiting line probabilities was based on two factors: the average number of operators required and the specific capacity assigned. As noted earlier, such an approach is warranted only under certain conditions. Capacity is assumed to be absolutely fixed. Thus, we neglected both the additional capacity that might be available through periodic overtime work and the reduced capacity that results from absenteeism. Furthermore, the average rate of input of jobs is assumed fixed. This rules out situations in which pronounced daily, weekly, or monthly cycles are present. It was assumed that jobs are processed in order of arrival. This might not be the case if some sort of priority system were used to schedule processing. Finally, it was assumed that jobs arrive at irregular intervals rather than at fixed times and that they take varying lengths of time to process.

Thus, the sample office situation we studied really represented the simplest kind of waiting line problem. Fortunately, many of the exceptional cases pointed out above may be present to some degree without substantially affecting the results. Even when this is not the case many exceptional situations may be handled quite adequately with more advanced techniques.

Simulation

In very complex and unusual cases where an exact statement of the relationship between capacity and delay time would be of extreme value an entirely different approach can be used. This is the technique of computer simulation.

Suppose, for example, in the study of a large purchasing department we wished to examine simultaneously various priority systems, various overtime policies and various capacities in respect to the handling of a large volume of routine requisitions. If, as might well be the case, direct analysis was beyond the scope of any known techniques the entire situation might be reproduced and simulated in a high speed computer. Actual data on the arrival of orders and the processing time required would serve as the basic input of the simulation. Waiting lines could be accumulated and the results recorded. This could be translated into the same sort of general picture of waiting line patterns discussed earlier in the simple example. Each capacity, priority system, overtime policy combination would have a particular pattern. These waiting line patterns could then be compared and the best particular combination of capacity, priority system and overtime policy could be selected.

Recently we carried out such a simulation of a fairly complex waiting line situation (in an entirely different context) on the I.B.M. 701 computer. The machine duplicated and printed out two years of actual experience in three minutes. Through approximately 70 of these three-minute runs we were able to explore a wide range of alternatives and find the particular region in which most profitable operations were available.

Considering the increasing availability of high speed computing equipment in individual companies this type of approach to the analysis of waiting line situations may be of particular importance. A certain amount of caution is advised, however. The simulation mentioned above required more than 500 man-hours of planning and programing time. And it was considerably simpler than the capacity, priority system, overtime policy problem outlined earlier.

Conclusion

Industry is becoming increasingly concerned about the need for fast handling of internal messages. While specific methods changes have done and will do much to reduce handling time, significant decreases frequently are attainable only through a direct attack on waiting lines. In this discussion we have examined something of the nature of waiting lines and have looked briefly at two approaches to waiting line problems—waiting line theory and computer simulation. Each of these methods is extremely new but each is extremely powerful. **s/p/a**

Mr. Feeney is a Senior Operations Analyst in the Economics Division of Stanford Research Institute, specializing in industrial operations research. He attended Harvard College, Harvard Business School and Columbia University. Mr. Feeney's work has been primarily in the fields of production control, inventory control and transportation problems.

Random Observation

A SHORT CUT TO EQUIPMENT UTILIZATION DATA

by J. Walker Voris

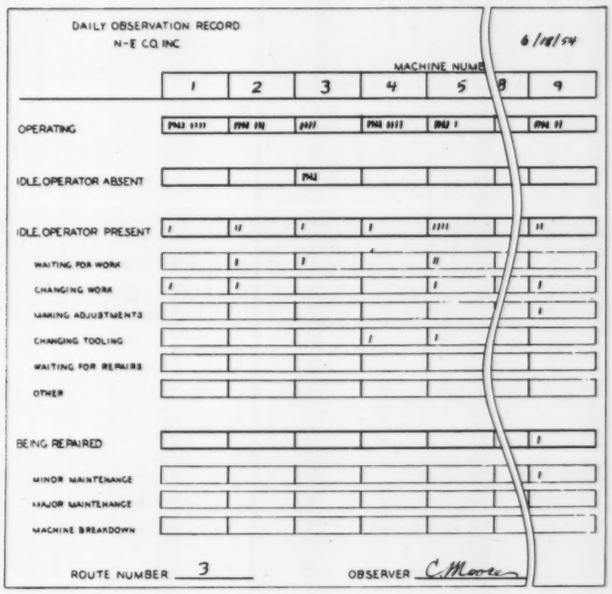


EXHIBIT I. A simplified daily operation method.

IN THE ABSENCE of industrial engineering studies how can management obtain assurance that present manufacturing equipment is fully utilized before it authorizes the purchase of additional equipment?

How can management satisfy itself that the possibilities of reducing costs are sufficiently assured to warrant the authorization of time and motion, methods-time measurement, or other studies?

Frequently, an answer to the above and similar questions may be obtained through the use of an adaptation of random sampling techniques. This method is referred to herein as "random observation." Similar adaptations have been referred to as "work sampling," "time sampling," and "ratio delay." Stated in the broadest terms, random observation is the technique of developing a picture of a complete operating cycle by tabulating the results of a series of observations made at random intervals.

The usual objective of random observation is the determination of the percentage of time that equipment is in productive operation. The method may also be used to determine the percentage of time that equipment is used to process each of several products or to obtain similar information. Within its limitations, the technique can be a versatile management tool. However, information obtained by random observation is necessarily limited to that which may be ascertained by direct observation, supplemented by a minimum of inquiry, and cannot be expected to substitute for time and motion or other industrial engineering studies.

No special training is required. Most industrial accountants and systems and procedures men, by their background and experience, are well equipped to initiate and supervise a random-observation program. During the planning stages, good judgment is important. However, during the observation stage, it is equally important that judgment play no part whatsoever. Employees who are trained to follow clerical routines without deviation are ideally suited as observers.

Although random observation is based upon the laws of probability and, therefore, subject to the disciplines of statistical theory, it is not necessary to understand the mathematics involved. If it is desired, the number of observations which are sufficient in any particular instance may be computed by formula, but, in most circumstances, the required number of observations may be determined from the charts included as Exhibits 2 and 3.

It is presumed that the concept of determining an operating cycle with predictable accuracy by making a sufficient number of observations at random intervals is accepted, and it seems unnecessary to discuss the statistical theories involved. The nature of statistical inference is presented concisely in most textbooks on elementary

statistics, and it is probable that most readers have been exposed to demonstrations or explanations of applicable statistical principles in connection with expositions of sequential sampling procedures, statistical quality control, or other statistical applications. Therefore, this article is limited to discussion of the steps involved in the initiation and execution of a random-observation program and the determination of the number of observations which are required.

The importance of thoughtful consideration of the objectives cannot be overemphasized. Much of the value of random observation comes from determination of such factors as the amount of productive time lost because of machine breakdowns, setting-up machines, operator absences, delays in supplying operators with work or supplies, operator downtime and similar occurrences. Information can be obtained only if it is specifically observed and noted. For this reason, the program should be explained to supervision and machine operators, and their ideas as to what information would be pertinent should be solicited. Production-control and cost-accounting personnel, as well as those responsible for making decisions based upon the results of the study, should be consulted.

The following considerations should be kept in mind when deciding what information is to be obtained:

1. Information should be limited to that which can be obtained by direct observation or by a single question which elicits a simple, concise answer.
2. Whenever possible, primary data should be obtained by observation alone. A machine is operating, or it is not operating. If it is not operating: it is undergoing repairs or it is standing idle; or the operator is present or he is away. Supplemental information should follow the primary classification of data.
3. Observers should not be required to distinguish, by observation, between types of operations. For example, adjustments made while equipment is in operation should be classified as "operating," and, if the time involved is significant, supplemental analysis of operations should be obtained by inquiry.
4. Questions should be directed to the machine operator or, when the machine is undergoing repairs, to the maintenance man. However, memorandum notations of information obtained from others may help to explain abnormal occurrences.

Although observation of a single piece of equipment or a single operation is feasible in some circumstances, the procedures outlined herein contemplate the sequential observation of several machines. It is not necessary for all machines to be of the same type. It is advisable, however, to obtain the same information about each piece of equipment.

The sequence in which machines are to be observed should remain unchanged throughout the observation period. However, because any machine may be the starting point for an observation tour, the route should be

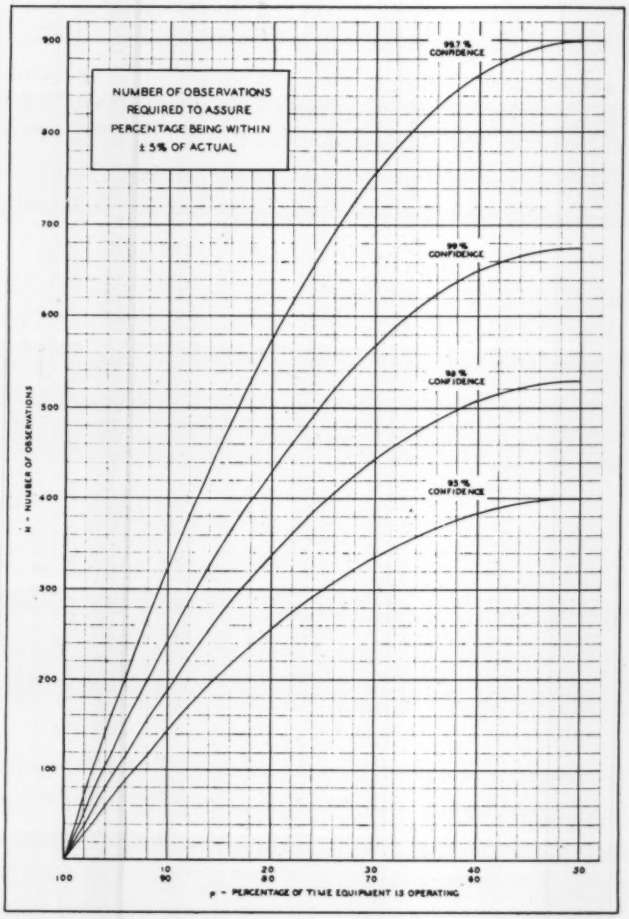


EXHIBIT 2. The margin of error is constant at ±5%, and the number of observations required is related to the percentage of time that equipment is operating for confidence levels of 95%, 98%, 99% and 99.7%.

continuous so that the observer can observe all machines in proper sequence regardless of the location from which he started.

The number of machines which can be studied at the same time depends upon both the complexity of operations and the amount of data to be obtained. The layout will also influence the number of machines which can be observed effectively, and careful planning of the observation route is necessary to assure minimum observation time. It usually should be planned so that the observer can complete the course within a period of 15 minutes or less.

The planning of the observation route should include the determination of the points from which the observation of each machine is to be made. In general, if there is a logical observation point, it should be used. Otherwise, the observation should be taken at the first point from which a clear view of the machine operation is obtained. It is helpful to indicate the observation point

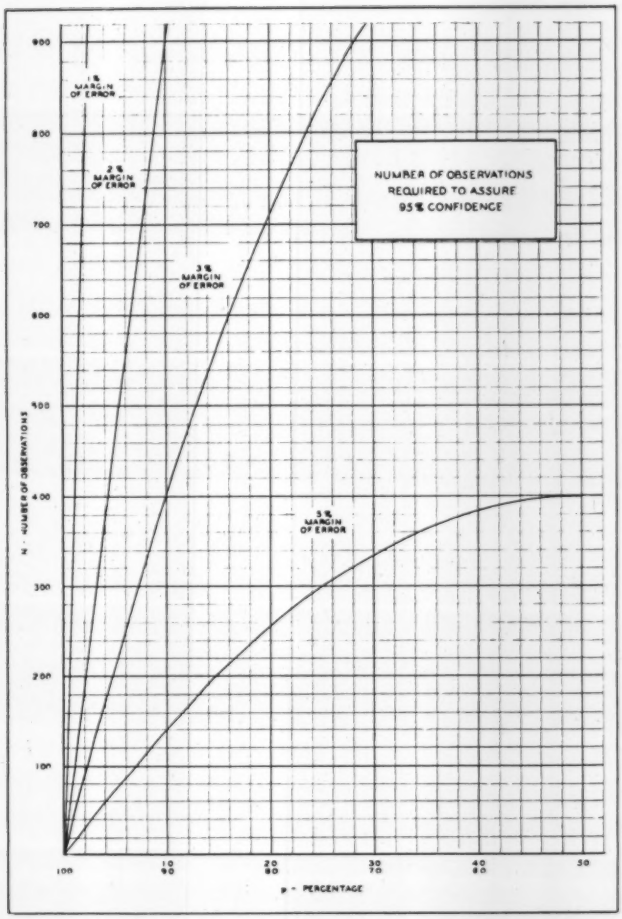

1% MARGIN OF ERROR
2% MARGIN OF ERROR
3% MARGIN OF ERROR
5% MARGIN OF ERROR
NUMBER OF OBSERVATIONS REQUIRED TO ASSURE 95% CONFIDENCE
N - NUMBER OF OBSERVATIONS
p - PERCENTAGE

EXHIBIT 3. The confidence level is constant at 95%, and the number of observations and the percentages are related for margins of error of 5%, 3%, 2%, and 1%.

by a symbol on the floor or by similar means, particularly if there is a possibility that more than one observer will be used.

When it has been determined what data are desired and which machines are to be observed, observation times can be programed. Scheduling of observation times is somewhat complicated by the fact that the number of observations which will have to be made will vary with the results. However, the number of observations can be estimated by forecasting the results and then determining the required number of observations by computation or by reference to the charts included as Exhibits 2 and 3. In general, estimates should be on the high side, as experience has indicated that the percentage of time a machine is not operating is greater than anticipated, and the higher the percentage (up to 50%), the greater the number of observations required.

Obtaining a series of truly random observations is extremely difficult. Even though the greatest care may be exercised in selecting random-observation times, the situation being observed may be subject to human control. This control may arise in various ways. Frequently it is related to the monthly business cycle. A typical example is the expediting of certain phases of production (with consequent disruption of production schedules) so that merchandise can be shipped and billed before the month end. When such periodic irregularities exist, the study should encompass at least one full month. The possibility that any abnormal event may fall within the observation period should be explored.

With such factors in mind, and taking into consideration the time required to complete a tour of inspection, the number of observations to be made each day should be set. If, for example, it is estimated that 300 observations would be required, observations may be made at the rate of 15 a day for one month, or 7 a day for two months.

Theoretically, observation times for each machine should be selected, at random, from the entire period in which observations are to be made. From a practical standpoint, the establishment of a fixed observation route and the random selection of a fixed number of daily observation times and starting points satisfactorily meet the requirements of random selection.

In a properly planned and programed random observation, it should be possible for any specific observation time for any machine to fall at any point of time during the operating day. Also, it should be possible for a second observation time for any machine to follow immediately the first observation. Specifically, if the program results in machine No. 1 being observed only on the hour, or at 10, 20, 30, 40, or 50 minutes after the hour, these conditions have not been met and there may be serious question as to whether the observations are truly at random. The following steps are suggested to assure proper random selection of observation times:

1. The interval between observation starting times should be established as the maximum time necessary to complete an observation tour (making an observation of each machine) and then go to the most distant machine to begin a new tour.
2. A schedule of starting times which encompasses the full operating day should be established. For this purpose, lunch periods and established rest periods should be excluded.
3. Observation times for each day should be selected at random. Each day's selection should be made from the full schedule of starting times.
4. The starting point for each observation tour should be selected at random. Each selection should be made from the full group of starting points (locations from which observations will be made).
5. No selection should be rejected.

Human choice cannot be depended upon to make selections which meet tests for randomness. Even methods

such as the successive drawing of cards are subject to human bias and should be avoided.

Tables of random sampling numbers provide the most satisfactory method of making selections. Any of the standard tables (1) is adequate for random observation purposes.

In making use of tables of random sampling numbers, each starting time and each starting point should be assigned a consecutive number. If, for example, intervals between starting times were five minutes and the schedule showed 92 starting times (2 ten-minute rest periods having been excluded), starting times would be numbered from 1 to 92, inclusive. Likewise, if 9 machines were included in the tour of observation, the machines should be consecutively numbered from 1 to 9.

In the foregoing example, columns of two-digit numbers would be used to select the starting time, numbers 93 and higher being disregarded, and a single-digit number would be used to select starting points, zero being disregarded. A starting-time number which repeats within one day is disregarded.

Selection of starting times and related starting points may be made as far in advance as desired. However, care should be taken not to repeat an identical series of random sampling numbers from the table.

Although usually slower and generally less satisfactory than the use of tables of random sampling numbers, the blind drawing of slips of papers or cards from a box will usually produce a selection which is sufficiently random in the circumstances if the slips of paper or cards are all exactly the same size, shape, texture, and weight and are completely mixed after each draw. It is advisable to check the slips periodically to ascertain that none has become damaged so that one might be drawn more frequently or less frequently than the others.

Other methods of selecting starting times and starting locations may be satisfactory, but, before they are used, they should be carefully reviewed to ascertain that they are not subject to bias.

Observers, before starting, should witness demonstrations of the operations of the machines which are to be observed and should become familiar with the route to be followed and the location of each starting and observation point. They should receive careful instructions

(1) Tracts for Computers No. XXIV, Tables of Random Sampling Numbers, by M. G. Kendall and B. Babington Smith, Cambridge University Press, London, 1939.

Statistical Tables for Biological Agricultural and Medical Research, by R. A. Fisher and F. Yates, Oliver and Boyd, London, 1938.

Tracts for Computers No. XV, Random Sampling Numbers, L. H. C. Tippett, Cambridge University Press, London, 1927.

SUMMARY OF OBSERVATIONS

N-E CO. INC.

MACHINE NUMBER 1

ROUTE NUMBER 3

MONTH		June																	July			
DAY	BRT FWD.	14	15	16	17	18	TO DATE NO.	%	21	22	23	24	28	29	30	1	2	TO DATE NO.	%
OPERATING	141	5	6	7	7	9	175	70											
IDLE, OPERATOR ABSENT	4	1					5												
IDLE, OPERATOR PRESENT																			
WAITING FOR WORK	6	1	3				10	4											
CHANGING WORK	31		1	2	3	1	38												
MAKING ADJUSTMENTS																			
CHANGING TOOLING	4			1			5												
WAITING FOR REPAIRS	3						3												
OTHER																			
BEING REPAIRED																			
MINOR MAINTENANCE	2						2												
MAJOR MAINTENANCE																			
MACHINE BREAKDOWN	9	3					12												
TOTAL	200	10	10	10	10	10	250												

EXHIBIT 4. A suggested summary of observation form.

as to the importance of reporting action exactly as it is at the moment the observation is made. It should be emphasized that even though a machine may have been in operation immediately prior to the observation and may resume operation immediately thereafter, if it is not in operation at the moment of observation, *it must be reported that way.*

Keep it Simple

The process of recording observations should be as simple as possible. A simplified daily observation record appears as Exhibit 1. It will be noted in the example that, if the machine is operating, this fact is noted by a single tabulating mark and no further inquiry is made. If the machine is not operating, primary distinction (by observation alone) is made as to whether the machine is undergoing repairs, whether it is idle because the operator is absent, or whether it is idle for other reasons. This primary observation is noted by a single tabulating mark.

At this point, the observer would proceed to the next observation point if the machine were operating or if the operator were absent. Otherwise, he would approach the machine operator or maintenance man and ascertain by inquiry the reason for the machine's being idle. This reason would be noted by a tabulating mark in the applicable box.

Frequently, notations by observers of reasons for operator absences and the extent of machine breakdowns are helpful in interpretation of results of operations. This information can be obtained by daily inquiries of foremen or others as to any factors which influence the operation of the machines under observation. Such data

should be entered on daily observation records as remarks and should not be used to modify the recording of observations.

It was suggested earlier that the random-observation procedure be discussed with machine operators during the planning stage. During these discussions and also during the period in which observations are being made, machine operators should be assured that it is the operation which is being observed, not the operator. Even so, it may be found that an operator will try to improve the recorded performance by making special effort to have the machine operating while it is being observed. This may be suspected if an observer notices that frequently the machine is stopped immediately after the observation has been made.

Second Observation

The existence of a biased situation of this type can be established by making a second observation of the suspected machine. Such observation would determine only whether or not the machine was operating and should be made surreptitiously from an observation point as far removed from the machine as possible. This second observation should be continued as long as there is any significant difference between the accumulated results of the two observations. If differences continue to the completion of the study, the results of both observations should be used as a basis for determining further action. In most cases, an average of the results of the two observations would be more acceptable than either of the separate results because a bias in the scheduled observation would tend to create an opposite bias in the second observation.

As with any technique based upon random sampling, the key to the method rests in obtaining the answer to the question, "How many observations are enough?" Before this answer can be obtained, two other questions must be considered:

1. What margin of error is acceptable?
2. How much confidence is to be placed in the answer?

Expressing the Results

Results of random observations are expressed in percentages of total time. If results were based upon an unlimited number of observations, such percentages theoretically would be the same as those obtained from a continuous observation of the operation during the same period. However, it is impossible to make sufficient observations to qualify as an unlimited number, and it becomes necessary to accept something less than perfect agreement between observed results and actual performance. The tolerance, or margin of error, which is acceptable varies with the circumstances. For example, it probably would not have significant effect upon decisions if the time a machine was reported as being in operation was 55% instead of an actual 60%. However, if management were particularly interested in loss of production caused by minor delays in supplying work to operators, a report of 1%, when machines were actually idle 6% of the time, might be substantially misleading.

Closely related to the acceptable margin of error is the factor of confidence which may be placed in the answer. Confidence is expressed in terms of the probability that the acceptable margin of error will not be exceeded. Again, circumstances dictate the selection of confidence percentage. A 95% probability that the answer is correct within the designated margin of error is satisfactory for most studies. However, under certain conditions, it may be considered advisable to obtain virtual certainty that the answer is within prescribed limits. Although 100% assurance is impossible, 99.7% or higher probability is feasible in many instances.

The acceptable confidence level and margin of error must be established before any estimate can be made of the number of observations which will be required. They should be set during the planning stage to permit proper programing. However, they may be modified, based upon preliminary results of observations.

The interrelationship between the factors of confidence and margin of error can be observed by comparison of Exhibits 2 and 3.

Periodic Summaries

Because it is impossible to determine the number of observations which must be made until a sufficient number have been made to complete the study, it becomes necessary to prepare periodic summaries of results to

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Mr. Voris, manager of the Management Accounting Department of the Los Angeles office of Lybrand, Ross Bros. & Montgomery, and associated with that firm for the past 18 years, is the author of the article, "How to Make Money Selling Tickets," which won first prize in national competition in 1949. A graduate of the University of Illinois, and a California certified public accountant, Mr. Voris is a member of the Los Angeles Chapter of SPA and was general chairman of the Sixth Annual Systems and Procedures Conference held in Los Angeles last October under the joint sponsorship of the Los Angeles and Southern California chapters of SPA and by the University of California at Los Angeles. He is a director of the Los Angeles Chapter of the National Assn. of Cost Accountants.

date. Although summaries may seem unnecessary during the early stages of an observation, they may disclose trends which make modification of the program advisable. If, for example, 300 observations were programed at 7 a day over a two-month period, and, during the first month, observation results indicated that 350 observations would probably have to be made, the additional 50 observations could be spread over the second month of observation, increasing the number of observations each day to 10.

Basis of Charts:

The following is presented for statisticians and mathematicians.

The charts appearing as Exhibits 2 and 3 are based upon the following formula:

$$N = \frac{p\ (1\text{-}p)}{s\ 2}$$

Where:

N = Number of observations required

p = Percentage of time equipment is operating, stated as a decimal

s = Standard deviation determined from the following formula:

$$s = \frac{E}{C}$$

Where:

E = Percentage of margin of error, stated as a decimal

C = Confidence, expressed in terms of deviation from the mean in units of standard deviation (x/s). Values of C (to closest 1/10) for certain levels of confidence are as follows:

Level of Confidence	Value of C
95%	2.0
96%	2.1
97%	2.2
98%	2.3
99%	2.6
99.7%	3.0

The formula used as a basis for random sampling differs from that used as the basis for "work sampling" or "ratio delay." as set forth by C. L. Brisley in an article in the July 1952 issue of "Factory Management and Maintenance," in that the ratio-delay margin of error applies to the percentage of time a machine is not in operation rather than to the total time. Thus, if a non-operating occurrence occurs 10% of the time, a margin of error of ± 5% computed in accordance with the racial-delay formula is equivalent to a margin of error of ½ of 1% under the random-observation formula. With a 95% confidence level, it would require 14,500 observations to assure results within this margin of error. As a contrast, under the random-observation formula, 900 observations will give equal assurance that results are within ± 2% margin of error.

It is believed that the formula used by C. M. Boswell & Associates, Los Angeles, under the name "time sampling," is similar to the random-observation formula.

A suggested summary-of-observations form is presented as Exhibit 4. In the hypothetical situation used as the basis for the example, management requires 95% confidence with a ± 5% margin of error, except that time lost because of delays in supplying operators with work is to be determined within ± 2% margin of error. It will be noted in the Exhibit that 250 observations made to June 18 showed that machine No. 1 had been operating 70% of the time and was idle 4% of the time because the operator was waiting for work. Reference to Exhibit 3 shows that when the final percentage is 70, approximately 335 observations will be required to obtain 95% confidence with ± 5% margin of error, and when the final percentage is 4, approximately 385 observations will be required to obtain 95% confidence with ± 2% margin of error. Thus, it can be expected that 385 observations will be sufficient. However, if upon completion of 385 observations it is found that the machine had been idle 5% of the time, an additional 90 observations (a total of 475) would be required to obtain the required assurance.

Watch for Trends

Interim summaries should be considered as indicative of trends only, and discretion should be used in releasing them. Seldom should interim results be disclosed to anyone who has authority to start action based upon such results. Final results of an observation may indicate an entirely different situation, particularly when there are irregularities in production schedules.

As a study nears completion, it may be found that sufficient observations have been made for some machines, whereas a number of observations must still be made for others. If the machines being observed are of the same type, it is usually advisable to continue observation of all machines until sufficient observations have been made of each machine. This procedure permits averaging of results without incurring the possibility that insufficient observations were made of the machines as a group. If machines are dissimilar and averaging is unlikely, individual machines may be dropped from the observation route as soon as sufficient observations have been recorded.

Possible applications of the random-observation method are so diverse (it has even been used to determine the time administrative employees were absent from their desks) that it can be used by almost any company. The program can be carried on with minimum cost and negligible disruption of production schedules. It does not require trained personnel. It is probable that anyone who has found this article interesting can plan and execute a random-observation program. It can be a valuable management tool. **s/p/a**

What is a Systems Man?

A SYSTEMS AND PROCEDURES INSTRUCTOR ARRIVES AT A DEFINITION OF SYSTEMS MEN BY FIRST DETERMINING WHAT A SYSTEMS MAN IS NOT

by William C. Gill

THE DIFFICULTY in devising systems and procedures principles which can be applied universally is well-known by systems and procedures people, and discussions of such broad aspects usually ends this way: You have to design the rules to fit the specific company environment. Perhaps this attempt at definition of the systems and procedures man's scope will end that way too, yet it is probably a good idea to try to provide broad definitions from time to time, so that in the cumulative we might come up with some sort of standard operation some day.

Let's try here to approach this definition backwards, to determine what a systems man is *not*—and see what we have left over.

First, we are not efficiency experts, and do we get mad when somebody tries to simplify our field of endeavor with that particular job description! Anybody who calls *himself* an efficiency expert, of course, is not only twenty years or so behind the times, but will meet only sneers and ridicule with such a claim. Business has "had it" from the experts, and wants no more of experting.

Systems and procedures people are not mere off-shoots from some of the more accepted specialized fields, either. For example "Industrial Engineering for the Office" is frequently heard in connection with systems and procedures. We are not industrial engineers and we are not confined to the office. We may approach problems of paperwork production intelligently just as industrial engineers approach factory production problems intelligently. We may spend most of our time studying systems in offices, and we may get into office layout problems as does the industrial engineer deal with factory layout. But transplant a pure industrial engineer into a complete systems and procedures program and tell him to put factory know-how directly to work on the paper? Never! It has been tried, but problems of inter-relationships in offices have been encountered in such magnitude that these men either become frustrated and scamper quickly back to the factory, or they come around; they become real systems and procedures people, leaving their industrial engineering behind.

"Auditing and systems are so closely allied that systems should be a branch of auditing." Now here is an oft-quoted thought that is pure humbug. Systems work is allied with bookkeeping, with personnel work—with everything. Systems work requires a combination of traits and training not often found in auditors; and, on the other hand, it is difficult to visualize a good systems man as predisposed to success in the role of auditor. The fact that many organizations operate reasonably successfully under this fallacious principle of audit-systems compatibility is beside the point, and one is prompted to wonder what heights could be reached if auditing and systems were divorced.

Auditors can be a fine source of projects for systems people; systems people should install systems with controls in keeping with good audit practices—but systems and procedures people are *not* auditors themselves. They should not construe their position as one of the self-appointed watch dog, exposing inefficient operations to

the scrutiny of the hierarchy. If, in the course of his work, the systems man sees the need of an audit then he should point this out to the proper deciding executive and the auditor should conduct the audit. If a new system is indicated as a result of the audit, then the systems man is called in. It is a personal observation that auditing and systems complement one another more effectively if they are organizationally separate.

You ask: "What if you can't afford both an audit staff and a systems staff?" The answer is, that if somebody must wear more than one hat due to the size of the company or condition of economics, the hat-changing must involve in each man a consistent pattern. There are other operations, such as office services, duplicating, etc., that are at least consistent with the management-staff position of systems. It takes two different breeds of cats to operate effective auditing on the one hand and good systems administration on the other.

Systems people are also not merely accounting systems specialists. You have heard the old idea, "If a man is a good accountant, he is a good systems man!" More humbug. Knowledge of accounting is one of the many attributes which will be of great assistance to the systems man, but accounting alone? Accountants often stress after-the-fact recording of information to the neglect of active, stimulation-and-control systems. They sometimes lack imagination, the broad management viewpoint so necessary to successful systems work.

It is no doubt true that a majority of successful systems people today are former accountants—this is natural and healthy. But they are *former* accountants; they left accounting and entered systems, bringing a wealth of experience upon which to build a new, full approach to better systems and procedures.

Systems people sometimes think they are executives. They are not. Of course they must have an outlook which is "top management" in nature—they may ultimately receive pay in the executive range, may develop prestige accorded executives, offices in executive row, secretaries, etc. But their position remains—when their work is strictly systems—staff, not line.

Mr. Gill majored in business administration, psychology and accounting at the University of Minnesota, and joined Douglas Aircraft Co., Santa Monica, in 1940, entering the forms and procedures department in 1941. He was supervisor of forms and procedures at the Douglas Aircraft Oklahoma City plant 1942-45; and did forms, service, printing and consulting work 1946-49. He returned to Douglas in systems analysis and since 1951 has been office manager, Tulsa Division, and serves on the faculty of University of Tulsa, teaching systems and procedures, using his own text.

No systems man in his right mind would *order* a given procedure into effect; for to do so he knows will almost insure its failure, no matter how "good" the procedure may be technically. Systems organizations are not issuing agencies for procedures or systems, even when backed by sufficient lateral agreement and executive blessing. The systems and procedures administrator who issues procedures over his own signature is invading the executive branch, and such an invasion is not consistent with his proper scope. He is staff, and not empowered to issue orders. And procedures *are* orders, once they have been made the matter of general agreement and executive approval.

Here's something a systems man definitely is not: a genius. Granted, a systems and procedures analyst will solve problem after problem which may have appeared insoluble for years. He becomes skilled at spotting weaknesses and waste quickly, and he develops powers of relating a "new" problem to an old solution. He becomes a walking library of management information, a lighthouse in the storm. He is—and you can believe this or not—sometimes actually thought of as a superior and amazing character. This is why so many leave systems and enter the executive branch of management.

But the systems man in this positive state of regard should not polish his fingernails on his lapels over it. He must realize that much of his learning is by rote, is the natural result of his scope and operation; in fact, he will be easier to live with if he will sell himself on the idea that "any fool could do the same thing."

A segment of erroneous thought accords systems people as those with mere sales ability. "If you can sell, you're a systems man." Not so, particularly in the sense that sales people encourage reluctant prospects to "buy" through the use of organized pressure. The ability to "put over" a sound idea of course is part of the systems man's job; if this is salesmanship it is a lot different than selling house siding or brushes.

"The systems man is just a business politician." Now we're getting into the ridiculous. The realism introduced by objective systems analysis and coordination is a force diametrically opposed to the "political" or horse-trading type of business analysis and changes.

There are no doubt other things which systems and procedures people are "not," but these appear to be those most widely distributed. So what do we have in the remainder as to what a systems man is?

Here is where we encounter the inevitable "it all depends on the situation" rule, and any attempts to define fully will create a chorus of controversy. But there are at least a few general concepts on which we might agree. It would be interesting to create further discussion of the following general principles, offered here, for purposes of such discussion, as universally applicable to

any relationships of systems and procedures to any group management situation:

1. Systems and procedures is a top management staff function.
   a. Systems and procedures should not operate in isolated areas, but should have effective concern with inter-departmental procedure and practice.
   b. Controllership, as distinct from pure accounting, qualifies as an area for placement of the systems and procedures function.
   c. Systems and procedures is most logically placed, however, as staff to the extreme top management —such as the president, general manager, etc.
2. Systems and procedures operates with no authority, but operates as a service agency to all.
3. Operating functions of a complete systems and procedures program should include, and should be limited to:
   a. A centralized forms and printing control program; inclusion of stationery supplies control is optional.
   b. A centralized procedures control program, including control of all published manuals.
   c. A work simplification program generally excluding direct manufacturing.
   d. A program to improve integrated systems through
      (1) Analysis and reporting of present systems.
      (2) Installing new systems after concurrence by all line management people involved.

It is submitted that any scope of operation lacking any of the above functions is not a complete systems and procedures program, and that any major functions in addition to the above are beyond and inconsistent with the true nature of systems and procedures as such.

We shall be most disappointed if no argument ensues. **s/p/a**

Book Review

OFFICE MANAGEMENT

By C. L. Littlefield and R. L. Peterson, 1956. (Prentice-Hall, Inc., New York 11, N. Y. Illustrated, $9.00).

Reviewed by James J. McDowell, Merrill Lynch, Pierce, Fenner and Beane, New York.

Littlefield and Peterson, the authors of "Office Management," have recognized what is perhaps the most noticeable trend in business organizational development in recent years, namely the elevation of office management to the role of top level administration. Considering the complexities of our modern business enterprise this rise was both necessary and inevitable. It has, of course, occasioned a number of pertinent and peculiar problems both within the field of office management itself and in its relation to the business organization as a whole.

Not the least of these problems is the formulation of a basic philosophy of office management. It is the feeling of the authors of "Office Management" that some examination of the aims and purposes of this field as a profession is necessary if it is to maintain its newly found position of eminence. This book attempts to "advance and clarify the theory of office-management." Starting with a recognition of its basic purposes, it attempts to fit together the various functions and duties to arrive at these ends.

This volume has been organized into sections that follow roughly the accepted functions of office management. It flows logically from the role of the office in management to more specialized office procedures. The book contains the usual management topics such as organizational analysis, office layout, records management and standardization techniques, and new and timely subjects such as electronic equipment, work simplification, etc.

Broadly speaking, the approach to each topic is from the standpoint of the office manager as a responsible part of top level management, and it is in their approach to the individual problems that the authors attempt to underline the need for a basic philosophy. The sections of the book on office machines and electronic equipment are noteworthy examples of this. The authors have not only given a richly detailed description of office machines —what machines are available, what they will do, and how they do it—but they have given some serious consideration to the organizational problems of "scientific management" and the often neglected danger points of automation.

As in any work of such scope, there arise questions of emphasis in the treatment of subject matter. Such a topic as statistical analysis of office functions, for example, is perhaps deserving of more attention. The problems and perils of personnel testing have likewise been given somewhat cursory examination. Such faults, however, are minor when viewed in the light of the volume's completeness, logical pattern of presentation. The authors have also done a distinct service in providing problem cases and study questions at the end of each chapter.

Littlefield and Peterson have achieved in their material both wider range and deeper penetration than is normally found in books of this nature. Valuable to students in the field of management problems as well as to practicing business men coping with these same problems, the book fills a real need for factual information, and furnishes a perspective for individual thought and study. Undoubtedly, "Office Management" will be a welcome addition to business literature and the office manager's library. **s/p/a**

Writing Standard Practice Instructions

by William B. Worthington

1. PURPOSE:
   a. To set forth a guide for deciding how to store and present information for the specific individuals needing and using it. The following are minimum standards:
      1) Accuracy.
      2) Unmistakable meaning.
      3) Logical sequence of presentation:—(to point of view of user).
   b. Management frequently desires improvement in:
      1) Communication of policies, methods, and directives.
      2) Understanding of objectives, relationships, and procedures.
      3) Standardization of operational practices.
2. SCOPE AND APPLICATION:
   a. For use by any person organizing information to be used.
   b. Limited to guidance—since person doing the job must use common sense to choose the right data and the best methods.
   c. Applies to assembling and handling information—regardless of level, subject, scope, media, or machines.
   d. Terminology is for standard practice instructions on paper.
   e. Principles are for company memory, whether on paper, film, punched card files, or electronic media for automatic use.
3. STAFF RESPONSIBILITIES:
   a. Whatever it takes to achieve adequate presentation of data.
   b. Conformance of instructions and directives to company policy.
   c. Coordination of interests of all departments—so that content of instructions will serve the best interests of the company.
4. REQUIREMENTS OR EFFECTIVE PRESENTATION OF STANDARD PRACTICE INSTRUCTIONS (SPI)
   a. Unmistakable meaning is necessary for clear communication.
      1) Facts presented in the SPI should be accurate, complete, and relevant.
      2) Sequence of presentation should be logical from the point of view of those who will have to use the SPI.
      3) Exact word or series of words for a particular meaning should be determined in accordance with dictionary definitions, established usage, and local custom. The difference in effect between the "right" word and the "almost right" word is like the difference in effect between "lightning" and "lightning bug."
   b. Salability relates the SPI to the reader, encourages approval by reviewers, and facilitates compliance by users of the SPI. Requirements for salability are as follows:
      1) Objectives stated in the SPI should be clearly attainable, necessary, and desirable.
      2) Identity of user should be clearly established, so that he has justification for using Company time in reading the SPI.
      3) Interests of user should be identified, so that he has a motive for making an effort to understand the SPI.
      4) Viewpoint of presentation should be the viewpoint of those who will use the SPI.
      5) Associated considerations should be brought to the user's mind, so that he can match and compare with what he knows, which in turn greatly increases his interest, comprehension, and the amount of the instruction that he will remember and put to use. Man-

agement objectives stand a much better chance of accomplishment if aims and text of the SPI are understood.

c. Ease of scanning is a necessary convenience for all who will have to read the SPI. It facilitates prompt review by Company officers and ready reference by users; it also forces better thinking in laying out the SPI. Requirements for ease of scanning:
   1) Over-all appearance of both written and graphic presentations should make sense to the user, before content is read or analyzed.
   2) Outlining should be carefully organized, in order to provide simplicity of understanding through simplicity of composition. This kind of simplicity is usually the result of very hard work.
   3) Responsibilities should be isolated and given proper emphasis, in order to identify the user and his interests.

d. Readability is necessary for the purposes of all those who must fully understand the SPI. Requirements for readability:
   1) Clear thinking leads to clear expression.
   2) Symbols used should be familiar.
   3) Words should be definite, simple and well-known by readers.
   4) Sentences should be short, direct and specific.
   5) Verb forms should be reasonably consistent with each other. When possible, without violating consistency, active verbs should be used.
   6) Separate ideas should be stated in separate units of the SPI.

e. Reasonable consistency with other Company communications saves time, simplifies operations, and improves the quality of conformance by users because:
   1) Familiarity with the mechanics of presentation frees the minds of users of the SPI to concentrate on the facts contained in the instruction. Mechanics of presentation, to-be familiar, should be consistent with the way user normally deals with the subject.
   2) Accuracy and speed of familiar method frees writers, draftsmen, and typists to concentrate on the ideas to be presented.
   3) Balance between consistency and flexibility should be maintained. Reasonable consistency does not imply rigidity. Flexibility is essential in matching the presentation to the user's viewpoint. **s/p/a**

Worth Reading

"How Computers Can Help to Create Their Own Programs"—Ben Conway, *Office Management*, October 1955.
Detailed technical presentation of how computers can be used in encoding material and in eliminating errors.

"Will New Methods of Data Processing Affect Organization Planning?"—Herbert O. Brayer, *American Business*, November 1955.
Presents comments of business leaders on the subject and concludes "it will not alter the trend toward decentralization. . . . It can, but need not, cause a movement toward centralization of data processing functions. The determining factor is the particular company involved, its size, its particular problems, products, methods, and system."

"How Ditto Made a Communication System Survey"—J. Dennis O'Brien, *American Business*, November 1955.
Detailed explanation of study made of three major means of communication (1) flow of written material within the building (2) verbal communication between persons within the building (3) verbal communication between persons inside and outside.

"The Smaller Company Faces Electronics"—Robert L. Lorimer, *NACA Bulletin*, October 1955.
Brief general statement of presently available mechanical devices and lists 8 specifications for an automatic accounting machine for a small office.

"Improving Order—Handling Procedure"—R. A. Gerlinger, *Office Executive*, September 1955.
Detailed case history of a problem faced by appliance distributor firm of 14 office and 31 shop employees handling 100 orders a day.

"Planning and Controlling the Production of Transcribers"—*Office Executive*, October 1955.
Detailed case history of controlling status of work in an insurance company's typing pool providing transcription service.

"Electronic Equipment—a means, not a mystery"—Robert T. Bruce, *NACA Bulletin*, October 1955.
General introduction to electronic data processing equipment. Includes an explanation of the mechanical workings of a computer.

"Organizational Effects of Electronic Equipment"—Robert A. Reitz and Walter M. Harris, *NACA Bulletin*, October 1955.
Discusses probable effects of electronic equipment on decentralized accounting organizations and predicts a shifting of responsibility to a centralized group.

"How to Measure Office Operations For Incentives"—W. Gilbert Brooks, *Management Methods*, November 1955.
Detailed exposition of installing and operating an office incentive plan in Pitney-Bowes Inc. In seven years, 124 of 450 office employees have been placed under incentives with estimated annual savings of $120,000.

"A Fresh Approach to Cutting the Cost of Executive Dictation"—Frank Griesinger, *Management Methods*, October 1955.
Comprehensive description of a study made prior to purchase of new dictating equipment by Lincoln Electric Company in Cleveland. Explains why particular equipment was selected and how it is used centrally in three different ways.

A Manager's Stake in Systems

"Boss, may we presume to say—"

No. 6 of a series by Leslie Matthies

SYSTEMS CAN DO A LOT for you and your organization. What they can do for you may be summarized in two statements:

1. Systems lowers your cost.
2. Systems gives you control.

Systems men are constantly trying to educate themselves, and their bosses. No, we don't mean telling the boss how to do his job.

But we *do* mean to tell the boss how he can make powerfully good use of the science of systems—if he only will.

Systems men see constant evidence to indicate that when a boss doesn't realize what systems can do for him, he doesn't use systems techniques. At other times, he may be using systems, but then nullify the results, without realizing it.

Sure, our bosses are busy men. So the burden is on us. We must point out, not only what systems can do for the boss, but also how sometimes the manager may reduce, or nullify the systems results he should get from his systems man's work.

If we can only get our bosses to consider the following:

1. Indicate by your own attitude and the attitude of your first line executives, that adherence to the systems principles is important. In other words give systems as much backing as you give any other important staff function.
2. Give verbal or written orders only when they are in harmony with the existing policies and procedures.
3. Trust and act on the facts revealed by a professional man's systems analysis.
4. Tell your systems man what you want done, but don't tell him exactly how to do the job.
5. Don't allow changes to be pyramided upon changes without systems analysis.
6. Provide for audit to see that procedures and policies are followed.
7. Ask your systems men to set up a hard-hitting reports system that will serve both you and your entire organization.
8. Discourage autonomous departmental operation. Keep department walls low.
9. Provide for a check on departmental procedures to see that they are written in harmony with your organization's broad procedures.
10. Keep your systems analyst informed on procedural and policy decisions.
11. Don't place your systems activity in a line operating department. Keep it on a staff basis. Reporting to you is best.
12. Encourage the setting up of standards for the various clerical operations such as, typing, correspondence and files.
13. Discourage the creation and maintenance of alibi paper. This will happen if you are "blaming" people who don't keep enough records to clear themselves.
14. Don't let departmental people set up forms and records as they see fit.
15. Don't expect overnight miracles from systems. You can expect control and lower costs, if you will give your systems analyst the time to do the job right.

A lot to watch out for, isn't it? But it needn't be a burden on you. Most of it your systems man can do for you, if you'll let him.

To do a good job for you, the thing he needs most is your "attitude." If other people in the place think—"Well, the boss seems to think this is important, so maybe it is," your systems man will jump for joy.

What's more important to you, he'll be able to give you systems that hum—and help you make money. **s/p/a**

"Conveyor and Telephone Recorder," *Management Methods*, September 1955.
Credit Exchange, Inc., provides 4,000 apparel manufacturers with up-to-date credit information on 300,000 potential customers. From 2,800 to 5,000 calls a day are processed. A conveyor transports request forms from a telephone operator to a file searcher and back again within a minute. A recorder is used to service requests not requiring immediate action.

"An IDP Order—Invoice System"—Walter T. Gibson, *The Office*, September 1955.
Explains how Rockwell Manufacturing Company's Delta Power Tool Division uses prepunched tab cards to produce regular order forms and punched paper tape automatically. The tape is placed on teletypewriters to notify warehouses. The cards are later used for statistical reports. The only typing required for the operation is the bill of lading.

"How to Use Procedure Charting"—William C. Nickell, *The Office*, November 1955.
Well illustrated introduction to flow chart preparation and use.

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